

does it differ? It seemed possible that the peculiarity lay in the nature of its radiation. To test this a prism was placed before the lens of the camera, which broke up the image of the spark into a series of spark images of different colour. The plate was exposed to the flashed spectrum of a single spark, then removed from the camera and exposed to the candle light, and developed. If the reversing effect was due to any peculiar radiation or wave-length we should find the reversal at that part of the spectrum where the effective radiation belonged, say in the infra red if the reversing power lay in long waves given out by the spark. It was found that the entire spectrum came out lighter on the negative than the fogged background. A second plate was exposed to the spectrum flash, then slightly fogged, and a second spectrum impressed on it in a different place. On developing, one spectrum came out light and the other dark. Clearly the effect does not depend on wavelength. It then occurred to me that the time-element might enter into the problem. The light of the spark is over in about $1/50000$ of a second, and it did not seem impossible that a bright light of exceedingly short duration might act quite differently on a plate from a weaker light of longer duration. This may be tested in a variety of ways. We may open the lens wide, impress the image of a single spark on the plate, and then stop the lens down and superimpose a number of spark images sufficient to make the total exposure the same in each case. This was the first method which I tried. In order to compel the successive sparks to pass over the same path, that their images might be superposed, I shut them up in a capillary tube. With the lens open wide enough to give the maximum reversing action, I passed a single discharge through the capillary. Stopping the lens down to one quarter of its former aperture, four discharges were passed through the tube. The plate was then fogged in the usual manner, and on development the single discharge was reversed, but the composite one was not.

Fig. 2 is from a plate showing this effect. The upper images are those of single discharges through the capillary, with different apertures of the lens; the lower images are those of double or triple discharges through the same tube. The left-hand side of the plate was exposed to the candle light for different amounts of time, by moving the screen over small distances during the exposure. Only the single discharges reverse, though the density of the images on the unfogged portion of the plate is the same.

This was very strong evidence that the duration of the illumination was the important factor. Some years ago I measured the duration of the flash of exploding oxy-hydrogen, finding it to be about $1/12000$ of a second. Possibly the flash of such an explosion would duplicate the effect. I exploded several glass bulbs filled with electrolytic gas, but found that the action was the same as that of ordinary light, it being impossible to get any reversal. The flash evidently lasted too long, or there still remained some undiscovered factor.

The difference between the action of spark light and the light of the oxy-hydrogen flash is shown in Fig. 3.¹ Plate "a" shows the effect of the explosion flash. Squares 1 and 2 received the light from an exploding bulb, the rest of the plate being covered. Squares 1 and 3 were then exposed to the light of the candle. Square 1, which has received the light from both sources, is the brightest, that is, the effects are additive, there being no reversal. Plate "b" shows the action of the light from the spark. Squares 1 and 2 were illuminated by the spark light, then squares 2 and 4 were exposed to the candle. In this case, square 4, which was illuminated by the candle, is brighter than square 2, which received both the spark light and candle light. In this case the effects are not additive, there being reversal.

To demonstrate conclusively that the time-factor was the only one, it was necessary to secure an illumination independent of the electric spark, and of as short duration. This was accomplished in the following manner: A disc 30 cms. in diameter was furnished with a radial slit 1 millimetre wide near its periphery, and mounted on the shaft of a high-speed electric motor. A second slit of equal width was arranged close to the rim of the disc, in such a position that the two slits would be in coincidence once in every revolution. This second slit was cut in the wall of a vertical chute, down which a photographic plate could be dropped. By means of a large convex lens of short focus, an image of the crater of an arc-lamp was thrown on

the point of coincidence of the slits. The intensity of the illumination transmitted by the slits when in coincidence was almost sufficient to char paper. The motor was now set in motion, and a plate dropped down the chute. On developing this plate, three images of the slit appeared, not at all over-exposed, though the plate was the fastest obtainable, and the intensity of the light while it lasted comparable to that at the focus of a burning glass. By measuring the distance between the images and the vertical distance through which the plate had fallen, it was an easy matter to calculate the speed of rotation, which was found to be sixty revolutions per second, the air friction of the disc preventing higher speed. The duration of the exposure will be the time occupied by the rim in travelling a distance equal to the width of the slit, or 1 mm. This was found to be $1/55000$ of a second, about that of the spark. The crucial experiment now remained. A second plate was dropped, and, before development, was exposed to the light of the candle. *The images of the slit were most beautifully reversed*, except at the centre, where the light was too intense. It seems, then, that we are justified in assuming that *the action of an intense light on a plate for a very brief time-interval decreases the sensitivity of the plate to light*. It is curious to contrast with this effect the fact that exposure to a dim light for a moment or two appears to increase the sensibility by doing the small amount of preliminary work on the molecules, which seems to be necessary before any change can be effected that will respond to the developer.

I am not prepared to say what the nature of the change effected by the flash is. Possibly some one familiar with the theory of sensitive emulsions can answer the question. I have tried using polarised light for the reversing flash, and then fogging one half of the plate with light polarised in the same plane, and the other half with light polarised at right angles to it. As was to be expected, there was no difference in the effects.

R. W. WOOD.

Physical Laboratory of the University of Wisconsin,
Madison, Wisconsin, October 20.

Experiments on the Floral Colours.

In 1837 the illustrious Berzelius wrote: "The red pigment of several kinds of berries has generally been regarded as a blue pigment reddened by an acid. This is not the case with all berries. I have examined the pigment of *Prunus cerasus* and of *Ribes nigrum*, which contain the same pigment, and this is not blue. Probably this has been surmised from the circumstance that the sap of these berries gives a blue precipitate with acetate of lead, but these precipitates are malate and citrate of lead, wherewith the pigment is combined." He found that, after separating these acids from the colouring matter, the latter yields a green and not a blue precipitate with acetate of lead: and, moreover, when to its aqueous solution a little milk of lime is added sufficient to saturate all the free acid, the supernatant liquid is red and not blue, which latter it would be if its natural colour was blue. He arrives at similar conclusions with regard to the red pigment of the autumn leaves of cherry, red currant, &c.

On the other hand, Julius Wiesner, of Vienna, in 1862 and 1872, by a series of experiments, endeavoured to prove that the compounds of anthocyan—i.e. the blue and red pigment of flowers, with lead, alkalis, &c.—are always blue, and it is only when anthocyan is present in the cell-sap simultaneously with a substance which is coloured yellow by alkalis, &c., that it passes by the latter body into green, which thus arises as a mixed colour. He found that by completely washing out (as he thought) this latter body from the petals by warm dilute hydrochloric acid, and then immersing them in solutions of lead and iron salts, they became intensely blue; hence he was led to conclude, contrary to Berzelius, that the original and actual colour of anthocyan was blue and not red.

During last summer I have performed a series of experiments on a number of flowers, with a view of settling the question in dispute, as above set forth. In the first place, it was deemed advisable to observe the effect produced in each case by immersing the fresh petal into ether saturated with ammonia. The results were as follows:—(1) Petals which became blue, e.g. peony, pink campion, deep red garden rose, sweet pea, vetch, mallow, balsam, geranium, fuchsia, scarlet rhododendron, crimson flax, blue centaurea; red daisy, periwinkle, lady's smock, became bluish-green. (2) Petals which became green, e.g.

¹ The details in this figure, and in two others sent by Prof. Wood, are too indistinct to be reproduced satisfactorily.—ED. NATURE.

anemone, larkspur, violet, willowherb, scarlet *tropaneum*, red rhododendron, bilberry, flowering currant, scabious, wild thyme, potato, forget-me-not.

The colouring matter was then withdrawn from these and other petals by macerating them for two days in cold methyl alcohol, the solution was poured off, evaporated to dryness, the residue taken up with warm water, and the solution after filtering tested as follows:—(1) One drop HCl or H^3PO_4 , followed by several drops of ammonia; (2) solution of acetate of lead followed, or not, by acetic acid; (3) solution of acetate of magnesium. The results are tabulated as follows:—

Name of flower.	Natural colour.	HCl and NH ₃ .	Acetate of lead.	Acetate of Magnesium.
Peony	red	deep blue-green	bluish-green	blue-green
Larkspur	blue	green	green	blue
Anemone	red	nearly blue	green	—
Violet	violet	blue flush	green	dark blue
Oriental Poppy	scarlet	blue at neutral point	green	green
Campion	pink	blue-green	—	—
Ragged Robin	red	blue	green (blue, acid)	green (blue, acid)
Garden Rose	deep red	green	bluish-green	green
Dog Rose	pink	dark green	green	—
<i>Pyrus japonica</i>	crimson	green	bluish-green	green
Clover	red	blue	green	green
Vetch	red	green	blue	—
<i>Vicia sepium</i>	red	blue-green	green (blue, acid)	—
Sweet Pea	red	blue	green (blue, acid)	green
Mallow	red	blue	green (blue, acid)	—
Fuchsia	red	blue	blue-green	—
Geranium	red	blue	red-purple	green
Flax	crimson	blue	(blue, acid)	red-purple
Flowering Currant	red	green	blue	green
Daisy	red	dark-green	green (blue, acid)	green
Dahlia	deep red	blue	green (blue, acid)	—
Scabious	blue	green	green (blue, acid)	green
Betony	red	green	green	—
Rhododendron	pink	dark green	dark green	deep green
Primula	red	green	green	—
Periwinkle	blue	blue-green	green (blue, acid)	—
Foxglove	red	green	green	—
Snapdragon	red	green	green	—
Hyacinth	blue	blue flakes	green (blue, acid)	green (blue, acid)
Tulip	red	red-brown	green	deep blue
Orchid	red	pure blue	green (blue, acid)	postea green (violet-blue, acid)

In a few cases the aqueous solution of the pigment, after acidification by HCl, was shaken up with amyl alcohol, and after allowing to separate, the lower acid liquid was withdrawn, and tested with excess of ammonia and of acetate of lead. In this way, rhododendron, red daisy, red tulip, violet, foxglove, *Vicia cracca*, red poppy, gave a brilliant pure blue coloration; while, on the other hand, flowering currant and woundwort gave greens with ammonia, but blue precipitates with acetate of lead. In order, however, to purify the pigment still more thoroughly, its alcoholic or aqueous solution was shaken up at intervals for two days with well-washed hide-powder, and the latter, after filtering off the liquid, was well washed and extracted with very dilute HCl. The bright red liquid thus obtained was treated successively with the aforementioned reagents. The result was extremely interesting; for while flowering currant and rhododendron gave greens, red tulip and purple orchis gave blues. In some cases the Wiesner's experiment was repeated, *i.e.* the fresh petals were warmed with dilute HCl, and the acid quite washed out with water, and the now reddened organs placed into solutions of acetate of lead and acetate of zinc, when rhododendron, flowering currant, violet (in some cells), foxglove, *Vicia cracca* (in some cells), became green; while, on the contrary, *Geranium pratense*, bugle, the rest of the cells of violet, and of *Vicia cracca* became blue. It was evident, therefore, that Wiesner's opinion that anthocyan is invariably blued by alkalis, &c., and never greened, was not confirmed; inasmuch as at least three petals, when treated in

the manner he prescribed, were distinctly greened, the presumption being that all yellow intermixture had been obviated.

The general conclusion which I think must needs be drawn from these my experiments is, that there are different stages in the development of the floral pigment. In the lower stages the natural colour is red, whatever the chromogen may be; and so far Berzelius was right. In the higher stages, on the other hand, the natural colour of anthocyan is blue, or rather (at least with some chromogens) it becomes capable of forming blue compounds or lakes with alkalis and certain metallic salts. Moreover, as I have laboured to show elsewhere, chromogens exist which, except under very exceptional conditions and circumstances, are incapable of producing a blue pigment; and these in all stages naturally develop into a red, the brilliancy of which, when contrasted with that of a blue accidentally obtained in an allied species (*e.g.* in flax), unequivocally attests its real, original, and proper character.

P. Q. KEEGAN.

The Colour of Flints.

An examination of the pebbles lying on the beach of the coast of the English Channel shows that while these are principally flints they vary considerably in colour.

The flints derived from the chalk cliffs surrounding this part or the coast, and from which the shingle is generally supposed to be derived, are, so far as my experience goes, invariably black, with a white coating on the exterior.

Only about one-third of the flints on the beaches of such localities as Eastbourne, Hastings, Brighton, Hythe, Folkestone, Dover, &c., or in the large accumulations at Dungeness and at the Chesil Beach are apparently derived from the adjacent chalk cliffs, the remainder being different shades of brown, grey, white and red, the former being the most prevalent. In some cases the outside coating is of a different colour to the interior of the pebble. It follows, then, either that the flints from the chalk undergo some chemical action, either internally or externally, while exposed to the air and salt water of the beach, which changes their colour, or the majority of them must have been derived from inland gravels.

The first theory does not seem feasible, as flints are to be found in raised beaches and other positions, where they have been deposited for long periods, still retaining not only their interior black colour, but also the white coating on the outside.

If these various coloured beach flints are derived from inland gravel beds, they must have been deposited under different conditions from those which now prevail, as there is no action in operation on the south coast which can convey the flints from inland to the sea. The age of some of these shingle beds must, therefore, be much greater than has been generally supposed.

There are isolated pockets of gravel at the top of the chalk cliffs in some places, which fall on to the beach where the cliffs are eroded by the sea; but these are too few in number to account for immense deposits such as those at Dungeness, Pevensey and Chesil.

Failing to obtain any light on this subject from geologists to whom I have mentioned the matter, and whose opinions vary as to the changes flints undergo, I venture to appeal to NATURE for a solution.

W. H. WHEELER.

Boston, Lincs., November 27.

THE PROPOSED CHANGES IN THE MATHEMATICAL TRIPPOS.

THE Cambridge Board for Mathematics has presented to the Senate a report on the Mathematical Tripos. This report recommends certain changes in the regulations relating to that Tripos. The following note contains an abstract of the proposals made by the Board:—

The schedule of subjects for Part I. of the Tripos has been reduced by the entire omission of some subjects (calculus of variations, elliptic functions, Bessel's functions, hydrodynamics, sound). Other subjects have been limited in extent (*e.g.* rigid dynamics, electricity, optics, astronomy and others). Care has been taken to specifically exclude parts of some subjects. The arrangement of papers is to be entirely changed and no papers are to be